U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
OFFICE OF QUALITY ASSURANCE

AUDIT REPORT M&O-ARP-00-06

OF THE

CIVILIAN RADIOACTIVE WASTE MANAGEMENT SYSTEM
MANAGEMENT AND OPERATING CONTRACTOR

AT

LAS VEGAS, NEVADA

FEBRUARY 7-11, 2000

Prepared by: _____ Date: _____
Donald J. Harris
Audit Team Leader
Office of Quality Assurance

Approved by: _____ Date: _____
Robert W. Clark
Director
Office of Quality Assurance

1.0 EXECUTIVE SUMMARY

This performance-based Quality Assurance (QA) audit was conducted on the processes and activities related to the Engineered Barrier System (EBS) Process Model Report (PMR) at the Civilian Radioactive Waste Management System Management and Operating Contractor (CRWMS M&O) offices in Las Vegas, Nevada, February 7-11, 2000. The purpose of the audit was to evaluate the effectiveness of the Analysis and Model Report (AMR) process and the quality of the four AMR products of the 23 AMRs that support the EBS PMR.

The audit team determined that the CRWMS M&O has effectively implemented the critical process steps relative to the EBS AMRs evaluated. The AMRs were determined to be technically adequate for the process and point in time of the evaluation, with the following exceptions: deficiencies were identified in the areas of Technical Product Development Planning (TDP), Review of Technical Products, Analysis and Models, Indoctrination and Training of Personnel, Software Management, and Control of Electronic Management of Data (refer to Section 5.0 for specific details). Based on the review of the AMRs, interviews of personnel, and examinations of the processes and documentation, the audit team determined that the EBS activities being conducted at the time of the audit meet the Office of Civilian Radioactive Waste Management (OCRWM) QA program requirements.

The audit team identified conditions adverse to quality that were addressed in five Deficiency Reports (DR) and one Deficiency Identification and Referral (DIR) document, which was added to the Extent of Condition of a previously-issued open deficiency document.

Previously issued DRs, LVMO-00-D-038 addresses the use of Unqualified Software (RADPRO/XTOOL and DRKBA) in development of EBS AMRs, and DR LVMO-00-D-039 addresses software (EXCEL 97 and MathCAD 7 Professional) that were not documented to the requirements of AP-SI.1Q, Revision 1, ICN 0. Both of these DRs were generated as a result of the M&O-ARP-00-04 Audit of the Unsaturated Zone Flow and Transport AMRs at Lawrence Berkeley National Laboratory (LBNL). Similar conditions adverse to quality in the area of software were identified during this audit and were incorporated into DRs LVMO-00-D-038 and LVMO-00-D-039.

DR LVMO-00-D-041 addresses Planning Statement of Work not consistent between documents, references to out-of-date Interface Control Documents (ICD) and comparison to alternate models was not performed. In addition, the TDP indicates that the output of the AMR ANL-EBS-MD-000026 will provide input to the Physical and Chemical Environment (P&CE), and the Water Distribution and Removal Model. The outputs are not identified in the AMR, and the P&CE Model is not indicated on the AMR/PMR-TPS

Logic Network. DR LVMO-00-D-042 addresses the AP-3.10Q checker and the AP-2.14Q technical reviewer's comments on the "In-Drift Corrosion Products" AMR were editorial in lieu of technical. A subsequent evaluation of the checker and technical reviewer qualifications fail to reflect technical competencies in all or a combination of chemical, metallurgy, corrosion or microbiology disciplines. DR LVMO-00-D-043 addresses the Checker's mandatory comments that were deferred to next revision. There are no provisions in the Administrative Procedures (AP-3.10Q, Revision 1, ICN 1, Analyses and Models) for deferral. DR LVMO-00-D-044 addresses the software module within NUFT v.2.0s that computes thermal radiation (usnt), had not been qualified prior to use. DR LVMO-00-D-045 addresses training where employees were reassigned from other CRWMS M&O departments and/or national laboratories, and the receiving manager did not assess the need for additional indoctrination and training for their employees who's assignments, positions, or implementing documents had changed. DIR 00-13 was referred to DR LVMO-98-D-055, which addresses that no procedure and/or no procedural steps were identified for the control of the Electronic Management of Data.

In addition, there were 33 recommendations resulting from the audit as documented in Section 6.0 of this report.

Evaluations performed at the Atlas Test Facility reflected that the Control of Instrumentation was exceptional. Out of Calibration Instruments were disconnected and tagged out. Instruments in current use had calibration stickers which reflected they were within their calibration frequency. Additionally, the EBS test handling processors were performing at a high level and providing precise data from the test setup.

2.0 SCOPE

The audit was conducted to evaluate the effectiveness of the AMR process for the development of the EBS PMR. The audit team evaluated the documented activities that constitute scientific and Performance Assessment Analyses and Models pertaining to the EBS. The related AMRs and supporting documents were examined to determine the effectiveness of the analysis in providing evidence to support the EBS.

The EBS AMRs will support the Total System Performance Assessment (TSPA) on the subject and serve as an important reference to the LA. The following process and products were examined as part of this audit:

- Work Package 1201213EM2, "EBS Performance Testing for PMR."
- Activity Evaluation, "Engineered Barrier System Performance Modeling," dated 07/12/99.
- WPP-EBS-PA-000003, Revision 00, "Work Package Planning Summary EBS PMR, Analysis and Documentation and EBS AMR Checking Deferred."

- TDP-EBS-MD-000015, Revision 01, "Development Plan for Ventilation Model."
- ANL-EBS-MD-000030, Revision 00, "Ventilation Model."
- Work Package 1201213EM1, "EBS Process Modeling for PMR."
- Activity Evaluation, "Engineered Barrier System Process Modeling for Process Model Report," dated 10/11/99.
- WPP-EBS-MD-000018, Revision 00, "Work Package Planning Summary for Engineered Barrier System (EBS) Process Modeling or Process Model Report (PMR) Site Recommendation."
- TDP-WIS-MD-000006 (no revision number) (dated 8/24/99). "Provide Sub-Models for the Physical and Chemical Environmental Abstraction Model for TSPA-LA."
- ANL-EBS-MD-000041, Revision 00, "In Drift Corrosion Products."
- TDP-EBS-MD-000011, Revision 01, "Development Plan for In Drift Thermal-Hydrological-Chemical Model."
- ANL-EBS-MD-000026, Revision 00, "In-Drift Thermal-Hydrological-Chemical Model."
- TDP-EBS-MD-000014, Revision 01, "Development Plan for Drift Degradation Analysis."
- ANL-EBS-MD-000037, Revision 00, "Drift Degradation Analysis."

The audit team conducted personnel interviews and examined documentation in accordance with the approved Audit Plan to evaluate the adequacy and effectiveness of the critical process steps for the development of the AMRs that support the EBS PMR.

2.1 Process Steps/Products/Documentation

The performance-based evaluation of process effectiveness was based upon the following:

1. Satisfactory completion of the critical process steps
2. Documentation that substantiates quality of data
3. Performance of trained and qualified personnel
4. Implementation of applicable QA program elements

The following critical process steps were considered during the evaluation of the AMR process:

- Resources:
  1) Planning (Work Package Planning Summaries/Technical Product Development Planning)
  2) Personnel: Use of knowledgeable, capable, competent individuals; qualification requirements
  3) Equipment (i.e., software/Measuring and Test Equipment)

- Methodology:
  1) Inputs to Analysis and Models
  2) Qualification of Data/Software
  3) Submittal of Data to Technical Data Management System (TDMS)
  4) Analyses, Modeling Development
  5) Model Validation

- Adequacy & Accuracy:
  1) Reviews (Checks/Technical)

- Deliverables:
  1) Analyses/Reports/Models
  2) Record Submittals

2.2 The audit included a technical evaluation of the adequacy and effectiveness of the AMR/PMR process. Details of the technical evaluation are documented in Section 5.4 of this report.

3.0 AUDIT TEAM MEMBERS/OBSERVERS

Donald J. Harris, Office of Quality Assurance (OQA), Audit Team Leader
Richard L. Weeks, OQA/QATSS, Auditor
Stephen D. Harris, OQA/QATSS, Auditor
Emily S. Jensen, OQA/QATSS, Auditor
George T. Harper, OQA/QATSS, Auditor
Harris R. Greenberg, Management Technical Support (MTS), Technical Specialist
David C. Sassani, MTS, Technical Specialist
Steve Sobkowski, MTS, Technical Specialist
Arthur A. Stein, MTS, Technical Specialist

There were six observers present during the audit:

Tamara Bloomer, US Nuclear Regulatory Commission (NRC), Headquarters
Bob Brient, US NRC, Center for Nuclear Waste, Regulatory Analysis
Goodluck Ofoegbu, US NRC, Center for Nuclear Waste, Regulatory Analysis
Richard Codel, US NRC, Headquarters
Hans Arlt, US NRC, Headquarters
Robert M. Latta, US NRC, Headquarters

4.0 AUDIT MEETINGS AND PERSONNEL CONTACTED

A pre-audit meeting was conducted at the CRWMS M&O Offices, Las Vegas, Nevada, on February 7, 2000. Daily debriefings were held to apprise the CRWMS M&O management and staff of the progress of the audit and of any potential conditions adverse to quality. A post-audit meeting was conducted at the CRWMS M&O Offices, Las Vegas, Nevada, on February 11, 2000.

Personnel contacted during the audit, including those that attended the pre-audit and post-audit meetings, are listed in Attachment 1, "Personnel Contacted During the Audit."

5.0 SUMMARY OF AUDIT RESULTS

5.1 Program Effectiveness

The audit team concluded that critical process steps applicable to the AMR/PMR process were effectively implemented; however, conditions were identified relating to procedure implementation, which resulted in the issuance of five DRs and one DIR referred to an existing DR. These deficient conditions adverse to quality are described in Section 5.5 of this report. In addition, recommendations are provided in Section 6.0 of this report.

5.2 Stop Work or Immediate Corrective Actions Taken

There were no Stop Work Orders or immediate corrective actions required as a result of the audit.

5.3 QA Program Activities

Attachment 2, "Summary Table of Audit Results," provides results for each critical process step evaluated. Attachment 3, "Summary Table of Audit Results for Procedure Compliance Evaluations," provides the results of procedure compliance evaluations. Details of the audit, including the objective evidence reviewed, are documented in the audit checklist. The checklist is maintained as a QA Record.

5.4 Technical Audit Activities

The AMRs evaluated were prepared to support the EBS/Analyses Modeling efforts. The audit team examined and reviewed the AMR reports, pertinent records, supporting documents, and conducted interviews of the AMR Authors, Checkers, and other Key Personnel.

The principle procedure governing the preparation of AMRs is AP-3.10Q, "Analyses and Models." The audit team examined the AMR reports and used the information in the Analyses/Models, along with the checklist, to structure the interviews of personnel. The AMRs were determined to be technically adequate for the process and point in time they were evaluated. It was determined through discussions with the authors and management that these AMRs may either be revised or rolled up into another AMR or PMR in the future.

AMR ANL-EBS-MD-000026, Rev. 00, IN DRIFT THERMAL-HYDROLOGICAL-CHEMICAL MODEL

Although determined to be adequate for its intended use, it is only because the final purpose of the AMR is to provide conceptual guidance within the originating organization for other work on subsequent AMRs.

There appear to be inaccuracies within the documentation. However, these are for aspects that do not impact the technical adequacy of the results for the intended use. Other issues found relate to the degree of justification of fundamental model concepts and assumptions in order to demonstrate the utility of the work for the intended use of the results. The documentation of the model calibration work is evaluated to be inadequate. The area of investigation in this work is not one for which standard techniques were applied. Thus, for such developmental work, the need is great for clear, comprehensive justification of model concepts and major assumptions, and for precise presentation of the work done. It appears that the technical checker made comments parallel to or overlapping some of the recommendations that are made as a result of this audit. In many cases the checker's comments were accepted, but incorporation was deferred to a later revision of the document. If deferred comments had been incorporated qualitatively, the documentation would have been improved in many of the areas found lacking in this audit. (Recommendations 4 through 9)

AMR ANL-EBS-MD-000030, REV. 00, VENTILATION MODEL

Although determined adequate for its intended use, it is only because it is a preliminary calculation, and the purpose was limited to confirming that 70% of the decay heat could be removed by ventilation during the 50-year preclosure period. The calculation is acceptable because of the limited nature of the

conclusion required, but lacks clarity of the documentation and completeness of the assumptions and methodology. (Recommendations 10 through 13)

AMR-ANL-EBS-MD-000037, REV. 00, DRIFT DEGRADATION ANALYSIS

The stated purpose of this Analysis and Design Report is to perform key block analyses in the repository subsurface facility area using qualified geotechnical data, analysis techniques and postulated loadings. The key block characteristics will be used for waste package and drip shield analysis and also to determine properties for use in water distribution and environmental modeling. This AMR conceptually provides an acceptable approach to define the site specific key block characteristics noted above subject to evaluating the AMR for conformance of the seismic evaluation with the NRC Standard Review Plan (SRP) referenced in the Project Seismic Topical Report. Further evaluation of the appropriateness of modeling assumptions including cracking extent, number of rockfall segments, consideration on non-vertical loadings, and the applicability of key block analysis in areas with significantly less cracking than other less competent areas should be performed. These proposed AMR recommendations have the potential to change the AMR conclusions. (Recommendations 14 through 24)

AMR-EBS-MD-000041, REV. 00, IN DRIFT CORROSION PRODUCTS

This AMR appears to be technically acceptable in terms of the methodologies used and conclusions conform to the TDP. However, the AMR could be improved by consideration of the recommendations. The AMR should be concise and free of ambiguous statements that could have multiple interpretations based on the reader's perspective, references should be clearly identified, and the basis for assumptions presented. (Recommendations 25 through 33)

5.5 Summary of Conditions Adverse to Quality

The audit team identified conditions adverse to quality that were addressed in five Deficiency Reports (DR) and one Deficiency Identification and Referral (DIR) document, which was added to the Extent of Condition of a previously-issued open deficiency document. In addition, two DRs, LVMO-00-D-038 and LVMO-00-D-039, generated as a result of M&O-ARP-00-04 at LBNL on software incorporated similar deficiencies from this audit.

5.5.1 Corrective Action Request (CAR)

No CARs were issued.

5.5.2 Deficiency Reports (DR)

LVMO-00-D-041

AP-2.13, Rev. 0, ICN 1, "Technical Product Development Planning"

Contrary to the applicable requirements, the statement of the purpose of work is not consistent within the document and the TDP, Referenced ICDs, and Organization Structures are not current. TDP indicates that output of the AMR will provide input to the P&CE and Water Distribution and Removal Model. These output uses are not identified in the AMR, and the P&CE Model is not indicated on the AMR/PMR TSPA Logic Network. TDP required comparison to alternate models was not performed.

LVMO-00-D-042

AP-2.14Q, Rev. 0, "Review of Technical Products" and AP-3.10Q, Rev. 1, ICN 1, "Analyses and Models"

LVMO-00-D-042 addresses the AP-3.10Q checker and the AP-2.14Q technical reviewer's comments on the "In-Drift Corrosion Products" AMR, were editorial in lieu of technical. A subsequent evaluation of the checker and technical reviewer qualifications fail to reflect technical competencies in all or a combination of chemical, metallurgy, corrosion or microbiology disciplines.

LVMO-00-D-043

AP-3.10Q, Rev. 1, ICN 1, "Analysis and Models"

Contrary to the applicable requirements, the Checker generated mandatory comments that were acknowledged by the AMR Author, but deferred to a future AMR revision. The AP makes no provision to defer comments. Additionally, the AMR may not be revised in the future, as determined by management; therefore, any valid comments would not be incorporated.

LVMO-00-D-044

AP-SI.1Q, Rev. 1, ICN 0, "Software Management," and AP-3.10Q, Rev. 1, ICN 1, "Analyses and Models"

Contrary to the applicable requirements, the software module within NUFT v.2.0s that computes thermal radiation (usnt) was not qualified prior to use. The AMR stated that the code NUFT (of which usnt is a part) was obtained from Lawrence Livermore National Laboratory (LLNL) Configuration Management, is appropriately used for the EBS application within the range of validation. The statement is not correct; the LLNL code NUFT v.2.0s was acquired with no testing available to support use of this usnt module.

LVMO-00-D-045

AP-2.1Q, Rev. 0, ICN 0, "Indoctrination and Training of Personnel"

Contrary to the applicable requirement, employees were reassigned from other M&O departments and/or national laboratories, and the receiving manager did not assess the need for additional indoctrination and training for their employees who's assignments, positions or implementing documents had changed.

5.5.3 Deficiency Identification and Referral

DIR-00-13 Referred to LVMO-98-D-055

QARD, Rev. 8, and YAP-SV.1Q, Rev. 0, ICN 1, "Control of the Electronic Management of Data"

The Process Control Evaluation for Supplement V forms for this activity indicated the function of initial input, modification and transfer apply. No procedure or other means was provided as objective evidence to control this activity.

5.5.4 Follow-up of Previously Identified Deficiencies

During the audit, corrective actions were evaluated relative to the significant conditions identified in the existing CARS that could impact the EBS AMR/PMR process.

CAR LVMO-99-C-001, TRACEABILITY OF DATA, CHECKING PROCESS AND TECHNICAL REVIEWS

The four EBS AMRs had correct references to the data shown on the associated DIRS list and the examples reviewed, and the DIRS list reflected the correct status of the data. When required, input was not available from a controlled source, the AMR originator properly

implemented AP-3.14Q, "Transmittal of Input," to obtain the required inputs, which were then included in the DIRS in accordance with AP-3.15Q, "Managing Technical Product Input."

The four AMRs AP-3.10Q Check Copies were evaluated and the process was determined to be satisfactory, except for AMR ANL-EBS-MD-000026, in which the mandatory comments were deferred to the next revision (LVMO-00-D-043). In addition, this AMR was not compared to alternate thermohydrologic models even at a conceptual level. The comparison was required by AP-2.13, "Technical Product Development Planning" (LVMO-00-D-041).

Independent technical reviews, in accordance with AP-2.14Q, "Reviews of Technical Products," were performed on two AMRs, ANL-EBS-MD-000026 and ANL-EBS-MD-000041, and were determined to be satisfactory.

CAR-LVMO-98-C-002, DATA DEFENSIBILITY

The DIRS was reviewed to determine the status of data. It was determined that the process for resolution of the TBVs has not been implemented for these AMRs. Data confirmation checklists were not yet completed for the Data Tracking Numbers (DTN) identified on the DIRS.

CAR LVMO-98-C-010, MODEL DEVELOPMENT

The two AMRs, ANL-EBS-MD-000026 and ANL-EBS-MD-000030, were evaluated as Conceptual Models. The Model Validation Criteria or Model Validation Plan was not present at the time of the audit. It was noted AP-3.10Q was in revision at the time of the audit. The revision should enhance the model requirements and terminology.

6.0 RECOMMENDATIONS

1. Revise AP-2.13Q to require the referencing of the AP-2.15Q, "Work Package Planning Summary" (WPPS) Document Identifier number, in addition to the Multiple Year Planning System (MYPS) number on the Cover Sheet, in order to cross-reference the Planning documents. (Configuration Control)

2. Revise AP-3.10Q to require the analysis/model purpose to reference the Planning documents (WPPS/TDP) it satisfies. Currently, no database is available that provides this type of information. It is necessary to search OCRWM Program Documents (plan database, WPPS/TDP) by the document title in order to retrieve the document.

3. The current procedure for TDPs (AP-2.13Q) requires listing of relevant ICDs. Apparently these documents are out of date with respect to the current organization of the CRWMS M&O, and while these are being cited in the TDPs, a disclaimer is being included to explain their irrelevance. Interface control and communications are critical to the success of the AMRs and PMRs. Recommend that either these documents be updated to reflect the correct organization, or reference to them to be deleted, and an explanation of how the interfaces and data exchange are being controlled.

AMR-ANL-EBS-MD-000026, REV. 00, IN DRIFT THERMAL HYDROLOGICAL-CHEMICAL MODEL

4. Revise inaccurate statements in the text. Specifically, this refers to the statements in: a) Section 3 that NUFT 2.0s was used within qualified range of validation; b) the first paragraph of Section 4.0 regarding qualified and unqualified data in the document; c) Section 5.7, page 15, that 68 mm/year is maximum long-term percolation flux; and, d) Section 6.5, result 9, that indicate the dominance of radiant heat transfer *offsets* the errors in the approximation of convective heat transfer.

5. Document the complete criteria used for selection of the NUFT 2.0s code. Although there appears to be a number of factors used to select the code (including porous media representation capabilities, QA status, and time), these are not included in the document.

6. Revise the inconsistent handling of the citation of sources for parameter values that all originated within the same source that was generated by the AMR originator's organization. Place parameter derivations within the actual document. Examples of required revisions are:

   The assumptions listed within Section 5.0 were supposed to be those not available in final documents. Only values that were traceable/referable to final documentation were supposed to be included within Section 4.0 inputs. However, this is not supported by the fact that the values listed as inputs in Section 4.1.3 (DTN-SN-9908T0872799.004) are referenced within that DTN to the AP-3.14Q Input Transmittal PA-SSR-99218.Ta (MOL.19990901.0312). The Input Transmittal (PA-SSR-99218.Ta, MOL.19990901.0312) was generated by the EBSO group as input to the Performance Assessment organization and should be the appropriate reference. This obscures the origination of those values that were generated within the department of origin and provides them a finalized source when none exists.

It appears that the Originator was perhaps confused about the actual origination of the values listed within Section 4.1.3. This is supported by the fact that the information listed as Assumptions in Sections 5.8 and 5.9 are referenced directly to the AP-3.14Q Input Transmittal, even though the values are also given with DTN: SN9908T0872799.004) in a manner identical to those cited within Section 4.1.3. This condition at least presents a convoluted/circular set of references for those values within Section 4.1.3. In addition, because the AMR Originator's department prepared the AP-3.14Q Input Transmittal PA-SSR-99218.Ta (MOL.19990901.0312), this AMR itself should have become the controlled source of the actual derivation of the parameter values contained within that transmittal in order to appropriately document those values.

7. Provide documented justification of model concepts and assumptions relative to the intended use of the results. Specific areas where this is needed are:

   - Potential effects on results from using thermal properties for backfill and invert materials that are not dependent on temperature or saturation, and for the waste package and drip shield that are not temperature dependent.

   - Potential effects on results due to the model implementation of the impermeable package resting directly on the invert, in particular, the potential restriction of vapor movement from the invert into the air gap under the drip shield.

   - Potential effects of alternate model approaches, specifically comparison of dual permeability models with the equivalent continuum model applied.

8. Identify appropriate Section 4.2 Criteria based on the NRC Issue Resolution Status Reports Criteria.

9. Provide clear and precise documentation of the calibration process for the NUFT 2.0s pseudo-porous medium parameters, including fixing inaccuracies in the documentation. This activity needs to be documented explicitly enough such that someone other than the originator would be able to reproduce the process.

ANL-EBS-MD-000030, REV. 00, VENTILATION MODEL

10. Variability and uncertainty in input data and assumptions needs to be addressed in the AMR. Consideration should be given to sensitivity analyses to determine the significance of varying input data and assumptions on the results of the calculations. Engineering evaluations and logical explanations can be used in place of sensitivity analyses where appropriate. Specific examples where this should be addressed in the AMR are for the:

- Convection coefficient
- Rock properties and stratigraphic thickness
- Number of drift segments in the model

The convection coefficient needs further discussion in the body of the AMR in both Sections 4 and 6. The authors actually considered 5 different approaches to calculating the convection coefficient, but only one method is documented in Appendix III. It is suggested that all of the methods considered should be identified so that the conservatism of the selected method could be discussed.

11. Although the Multi-Flux program is not yet qualified, it should be considered as a way of verifying the current analysis methodology. In addition, a number of assumptions need to be added, and additional discussion and justification provided for others. It would help, for example, to provide justification for the assumption of constant air intake temperature of 25°C for the entire 50-year emplacement period. Assumptions should be added for the decay heat curves assumed for the DHLW and navy spent fuel (assumed to have the same decay heat curve as CSNF, but not stated explicitly).

12. Assumptions need to be added for the air properties – assumed to be at atmospheric pressure, temperature effects on density, velocity, and heat transfer coefficient neglected, etc.

13. The first and sixth bullets in Section 6.3.2 should be deleted since they do not apply to the current analysis, but were descriptive of the LADS EDA II design.

ANL-EBS-MD-000037, REV. 00, DRIFT DEGRADATION ANALYSIS

14. The analysis, Table 4, should be revised to address seismic input values needed to satisfy the Project Seismic Topical Reports, NRC Review Plans, or the SRP referenced in the Topical Reports, specifically for:

    - The derivation of acceleration values shown, including the effects of free field strains

    - The acceleration values should consider three components of motion.
    - Provide rationale for using 5 to 10 Hertz frequency ranges with unknown damping rather than the zero period acceleration, as specified in the SRP.

    - Identify specifically the number of events in the time period of interest.

15. Section 5.1 – show that the adequacy of the assumption regarding radius multiplier has been demonstrated independently by sensitivity analysis for the example.

16. Section 6.3 – the analyses approach should be revised to address:

    - Probabilistic effects in mapping.
    - Describing progressive joint movement analysis approach, including probabilistic effects.
    - Loading sequence – initial period of thermal load with or without concurrent seismic events followed by a period of lower thermal load with multiple seismic loads.
    - Describing how the effects of water variations will be addressed.

17. Section 7 – Table 16 shows lower layer is not controlling layer rock size. This needs to be addressed. In addition, changes due to other comments can influence this change. The fifth bullet indicates it is favorable to rotate the drift from 108 degrees to 75 degrees. However, Figure 17 max block versus drift orientation does not reflect this to be the case.

18. Revise data presentation to show differences in layer properties, especially jointing.

19. Section 6.3.4 – In paragraph 1, seismic considerations are listed as differential rock block accelerations and tangential joint loads. The AMR should also address or justify not addressing body loadings and increased normal joint loads.

    - In paragraph 2, degrade the shear wave velocity for the free field strain.
    - Table 10 – Verify this table considers three components of input motion as required by the SRP.

20. AMR, Section 6.0, justify the use of Key Block Analysis in an area (lower lith.) without many key blocks.

21. Section 6.4.12, demonstrate that horizontal effects are adequately addressed.

22. On Attachment V-2, show the Peak Ground Acceleration of 0.43G used for the UDEC static computer model is equivalent to velocity of 34 centimeters/second in the UDEC dynamic computer model.

23. On Attachment V-2, justify the change in cohesion and friction angle between the static and dynamic case.

24. Software DRKBA vs. 3.3 needs to be included on the DIRS. It has a To Be Verified (TBV) number, but is not referenced on the DIRS as required by procedure.

ANL-EBS-MD-000041, REV. 00, IN DRIFT CORROSION PRODUCTS

25. "Reducing" conditions with "de-aerated" conditions in report Sections 6.2.1.2, 6.5.2.2, and 6.5.3.1 appear to be confusing and should be clarified.

26. AMR Section 6.2.1.2 - Revise to explain that high temperature tends to reduce or mitigate corrosion due to lower oxygen and presence of a diffusion layer.

27. AMR Section 6.2.1.2 - The variability in $HC0_3$ could not be explained and was stated to have no impact. This should be clarified in the AMR.

28. The AMR should identify what the assumed corrosion rates are in Section 6.5.2.4.

29. Identify the compelling factors in AMR Sections 6.5.3.2 and 6.5.3.1 (second paragraph).

30. Explain how plugging would occur in AMR Section 6.5.3.2.

31. Identify the source of $HC0_3$ variability and impact on the model in AMR Section 6.2.1.2.

32. Document the bases for assumptions in AMR Sections 5.8 and 6.4 where elements <1% have no effect.

33. Address if definition of salt generation and partitioning will affect the logic in AMR Section 6.2.1.2.

7.0 LIST OF ATTACHMENTS

Attachment I, Personnel Contacted
Attachment II, Summary Table of Audit Results
Attachment III, Summary Table of Audit Results for Procedure Compliance Evaluations

ATTACHMENT 1

PERSONNEL CONTACTED

Name	Organization/Title	Pre-Audit Meeting	Contacted During Audit	Post-Audit Meeting
Andrews, Robert	M&O/Duke, Manager	X		X
Arlt, Hans	NRC, Observer	X		
Beesley, John	M&O/MK, Checker	X	X	
Belanger, Ruth	M&O/TRW, Team Lead, Reference Control		X	
Bhattacharyya, Kalyan	M&O/MK, Department Manager	X	X	X
Bailey, Jack	M&O/TRW, Director			X
Blaylock, Jim	OQA/DOE, Engineer	X		X
Bloomer, Tamara	NRC, Observer	X		
Brient, Robert	CNWRA/NRC, Observer	X		X
Burningham, Andrew	M&O/TRW, QA Analyst		X	X
Chesnut, Dwayne	M&O/LLNL, Department Manager	X	X	X
Clark, John	M&O/MK, Staff Engineer	X	X	X
Clark, JK	M&O/TRW, Director, WMRF		X	X
Clayton, Rob	M&O/URSGWCFS		X	
Codell, Richard	NRC Observer, Sr. Hydraulic Engineer	X		X
Doyle, John	OQA/QATSS, QA Specialist, Sr.			X
Elayer, Bob	M&O/MK		X	
Eshleman, Michael	OQA/QATSS, Sr. QA Specialist		X	X
Fei, Duan	M&O/MK, Geotechnical Engineer		X	
George, Stephen	M&O/URSGWCFS, Assistant Director	X		X
Gonzalez, Jaime	DOE/OPE, General Engineer	X	X	X
Glasser, William	OQA/QATSS, Corrective Action Lead			X
Greenberg, Harris	MTS/S&W, Technical Specialist	X		X
Greene, Hank	OQA/QATSS, Manager	X		X
Harper, George	OQA/QATSS, Auditor	X		X
Harris, Stephen	OQA/QATSS/SAIC, Auditor	X		X
Hasson, Robert	OQA/QATSS, Audit Lead			X
Hayes, Larry	M&O/TRW, Manager, Systems			X
Higgins, Tom	M&O/FD, Engineer		X	X
Hodgson, Betty	M&O/TRW, SCM Manager		X	X
Howard, Cliff	M&O/SNL, Principle Investigator		X	
Howe, Bonnie	M&O/SNL,		X	
Jensen, Emily	OQA/QATSS, Auditor	X		X
Jolly, Darren	M&O/Duke, Engineering Services		X	
Kalia, Hemendra	M&O/LANL, EBS Test Coordination	X	X	
Kam, James	M&O/MK, Hydrologist/Engr.		X	
Kessel, Dave	M&O/SNL		X	

Name	Organization/Title	Pre-Audit Meeting	Contacted During Audit	Post-Audit Meeting
Kicker, Duane	M&O/MK, Sr. Geotechnical Engineer		X	
Kramer, Norm	M&O/MK, Test Coordinator	X	X	
Latta, Robert	NRC, Observer	X	X	X
Lev, Ovadia	M&O/TRW, Data Coordinator		X	
Lin, Ming	M&O/MK, Technical Engineer		X	
Lugo, Mike	M&O/TRW, PMR Manager	X		X
MacKinnon, Robert	M&O/SNL		X	
McDaniel, Mary	OQA/QATSS, Sr. QA Specialist			X
McGrath, Michael	M&O/TRW, Configuration Management		X	
McKenzie, Daniel	M&O/ FCF		X	
Mueller, Terry	M&O/TRW, QA Engineer			X
Neider-Westermann	M&O/MK, Senior Geologist			X
Ofoegbu, Goodluck	CNWRA/NRC, Observer	X		
Opelski, Ed	OQA/QATSS, Manager	X		
Peters, John	M&O/MK, Manager, Engineering	X	X	X
Powe, Richard	OQA/QATSS, Sr. QA Specialist			X
Pye, John	M&O/MK, Manager	X	X	X
Quittmeyer, Richard	M&O/Site Integration Department		X	
Rogers, Ralph	MTS/BAH, Coordinator			X
Sassani, David	MTS, Technical Specialist	X		X
Schreiner, Randolph	M&O/MK, Senior Staff	X	X	X
Sobkowski, Steve	MTS/Golder, Engineer	X		X
Stein, Arthur	MTS/SWEC, Technical Specialist	X		
Theirs, Gerald	M&O/MK, Geoengineering Lead		X	
Threatt, Dennis	OQA/QATSS, Sr. QA Specialist	X		X
Weeks, Richard	OQA/QATSS, Engineer	X	X	X
Weiser, Jerry	M&O/SAIC, Manager, Records Management and Document Control		X	
Wemheuer, Robert	M&O/FD, Department Manager			X
Wilkins, Dan	M&O/TRW, Director	X		X
Woods, Mary	M&O/FD, Engr. Document Control		X	
Yang, Hang	M&O/MK, Mining Engineer		X	X
Younker, Jean	M&O/TRW, Director	X	X	X
Zinkevich, Fred	M&O/TRW, PM Quality Coordinator	X	X	

Legend:

BA&H – Booz, Allen & Hamilton, Inc.
CNWRA – Center for Nuclear Waste Regulatory Analysis
DOE – U.S. Department of Energy
FCF – Framatome Cogema Fuels
FD – Fluor Daniel
LANL – Los Alamos National Laboratory
LLNL – Lawrence Livermore National Laboratory
MK – Morrison Knudsen
MTS – Management Technical Support
NRC – Nuclear Regulatory Commission
OPE – Office of Project Execution
OQA – Office of Quality Assurance
QATSS – Quality Assurance Technical Support Services
SAIC – Science Applications International Corporation
SNL – Sandia National Laboratories
SWEC – Stone and Webster Engineering Corporation
TRW – TRW Environmental Safety Systems, Inc.
URSGWCFS –Woodward-Clyde Federal Services

ATTACHMENT 2, CHECKLIST-02

SUMMARY OF TABLE OF AUDIT CRITICAL PROCESS STEPS

Products	Critical Process Steps	Detail Checklists	Deficiencies	Recommendations	Process Effectiveness	Product Adequacy	Overall
000026 000030 000037 000041	Planning	Checklist-01, Pgs 4-8 Checklist-02, Pgs 41-43, 49	LVMO-00-D-041	1, 2 & 3	UNSAT	SAT	SAT
	Training/Qualifications	Checklist-01, Pgs 1-3 Checklist-02, Pgs 56	LVMO-00-D-043 LVMO-00-D-045		SAT	SAT	SAT
	Equipment M&TE/Software	Checklist-01, Pgs 44-47, 51-54 Checklist-02, Pgs 14, 44-46, 48	LVMO-00-D-038* LVMO-00-D-039* LVMO-00-D-044	9, 11, 24	UNSAT	SAT	SAT
	Inputs to Analysis/Models	Checklist-01, Pgs 30-35 Checklist-02, Pgs 3-13, 16-24, 26, 27, 31-40, 46-49, 51, 54-56	N/A	6-10, 12, 14-18, 20-28, 30-39 4-8, 10, 12-15, 16, 23, 25-33	SAT	SAT	SAT
	Qualification of Data/Software	Checklist-01, Pgs 55-59	N/A	N/A	N/I	N/I	N/I
	Submittal of Data to TDMS	Checklist –01, Pgs 60-63	N/A	N/A	N/I	N/I	N/I
	Analyses/Model Development	Checklist-01, Pgs 17-24 Checklist-02, Pg 4	N/A	19	SAT	SAT	SAT
	Model Validation	Checklist-01, Pgs 19-23 Checklist-02, Pgs 15, 30, 42, 48, 50-54	N/A	N/A	SAT	SAT	SAT
	Reviews Checks/Tech	Checklist-01, Pgs 9-11, 17-24 Checklist-02, Pgs 40, 53	LVMO-00-D-042 LVMO-00-D-043		UNSAT	SAT	SAT
	Records	Checklist-01, Pgs 48-50	N/A	N/A	SAT	SAT	SAT

Legend:
SAT – Satisfactory
UNSAT – Unsatisfactory
N/I – Not Implemented

* Previously issued during audit M&O-ARP-00-04; however, incorporated software deficiencies identified during this audit.

ATTACHMENT 3

TABLE OF AUDIT RESULTS FOR PROCEDURE COMPLIANCE EVALUATION

QARD Element	Implementing Document	Details Checklist	Deficiency Reports	CDA	Recommendations	Program Adequacy	Procedure Compliance	Overall
2.0	AP-2.1Q	Pgs 1-2	LVMO-00-D-045	N/A		SAT	UNSAT	SAT
	AP-2.2Q	Pgs 3-	LVMO-00-D-043	N/A		SAT	SAT	SAT
	AP-2.13Q	Pgs 6-8	LVMO-00-D-041	N/A	1, 3	SAT	UNSAT	SAT
	AP-2.14Q	Pgs 9-11	LVMO-00-D-042	N/A		SAT	UNSAT	SAT
	AP-2.15Q	Pgs 4-5		N/A		SAT	SAT	SAT
	QAP-2.0	Page 4		N/A		SAT	SAT	SAT
	QAP-2.3	Pgs 12-14		N/A		SAT	N/I	N/I
3.0	AP-3.4Q	Pgs 15-16		N/A		SAT	SAT	SAT
	AP-3.10Q	Pgs 17-24	LVMO-00-D-042 LVMO-00-D-043	N/A	2	SAT	UNSAT	SAT
	AP-3.11Q	Pgs 25-28		N/A		SAT	N/I	N/I
	AP-3.12Q	Pgs 29-		N/A		SAT	N/I	N/I
	AP-3.14Q	Pgs 30-31		N/A		SAT	SAT	SAT
	AP-3.15Q	Pgs 32-35		N/A		SAT	SAT	SAT
	AP-3.17Q	Pgs 36-37		N/A		SAT	N/I	N/I
6.0	AP-6.1Q	Pgs 38-43		N/A		SAT	SAT	SAT
12.0	YAP-12.3Q	Pgs 44-47		N/A		SAT	N/I	N/I

ATTACHMENT 3

TABLE OF AUDIT RESULTS FOR PROCEDURE COMPLIANCE EVALUATION

QARD Element	Implementing Document	Details Checklist	Deficiency Reports	CDA	Recommendations	Program Adequacy	Procedure Compliance	Overall
17.0	AP-17.1Q	Pgs 48-50		N/A		SAT	SAT	SAT
SI	AP-SI.1Q	Pgs 51-54	LVMO-00-D-038	N/A		SAT	UNSAT	UNSAT
			LVMO-00-D-039	N/A		SAT	UNSAT	UNSAT
			LVMO-00-D-044	N/A		SAT	UNSAT	UNSAT
SIII	AP-SIII-.2Q	Pgs 55-59		N/A		SAT	N/I	N/I
	AP-SIII.3Q	Pgs 60-63		N/A		SAT	N/I	N/I
SV	YAP-SV.1Q	Pgs 64-65	DIR to LVMO-98-D-055	N/A		SAT	UNSAT	UNSAT